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ABSTRACT

The focus of this document is on descriptions of calculators, microcomputers, and related educational technology and materials. Calculators are viewed as innovative teaching tools that can have both practical and pedagogical functions in the classroom to enhance understanding and achievement in mathematics. Microcomputers are seen as glorified calculators, that may replace calculators since they perform calculator functions and are additionally easily programed to store and retrieve specific data, ask questions, and evaluate and report students' responses. A comparative list of features of some of the most popular microcomputers is provided. The report concludes by noting that calculators and microcomputers can benefit students by: (1) reinforcing the basic skills;; (2) helping in basic reasoning skills; (3) reinforcing problem-solving ability; (4) promoting logical thinking; (5) encouraging creativity; (6) developing concentration and independent learning; (7) broadening technological experiences; (8) providing stimulation and motivation; (9) developing mapreading skills; (10) helping to develop number sequencing concepts; (11) aiding in discovering mathematical concepts; and (12) developing music skills. (MP)

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USING CALCULATORS AND MICROCOMPUTERS
WITH EXCEPTIONAL CHILDREN

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To what extent can calculators and microcomputers be successfully used with exceptional children? This inquiry was the basis of a Chicago State University workshop by the National Science Foundation. Participants included administrators, teachers, librarians, and consultants working with exceptional children. The workshop included lectures, demonstrations, and hands-on experiences and discussions. This paper will present the activities in the format of an article rather than a report.

The evaluation of technology in the school saw the introduction of teaching machines, programmed materials and educational television in the 1960's to hand-held calculators in the 1970's and minicomputers in the 1980's. The low cost and availability of calculators have increasingly made them an accessible instructional tool for all students. The calculator can be an innovative teaching tool to enhance understanding and achievement in mathematics.

The calculator has two applicable functions in the classroom, a practical function, and a pedagogical function. As a practical function, the calculator is considered as a device much like an eraser and chalk and paper and pencil -- a tool that can do the work involved in tedious arithmetic computation. The calculator saves time and reduces the anxiety of the student.

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The pedagogical function of the calculator is much like a textbook, flashcards, or a manipulative device; it facilitates learning and enhances understanding and competence.

For the exceptional or handicapped student, the calculator can be the "least restrictive" learning device. The practical function of the calculator involves obtaining a usable answer with the least effort in the minimal time. Since the calculator is fast and effortless, techniques of trial and error and the reinforcement of the correct answers can easily be found.

The extent of applicability of calculators with handicapped children will vary from individual to individual. Many handicapped students function well with one digit numbers using paper and pencil calculations. When it comes to multiple digit numbers, paper and pencil calculations may be beyond their capabilities. But the calculator provides a practical bridge between success and failure. It permits the student to progress to a higher level of competence. Many handicapped students lack good memory retention. In the past, multiplication and addition tables and charts were the only personal reference for students attempting to recall the basic arithmetic facts. The calculator not only provides the basic facts, but allows the student to learn the facts that are beyond the traditional tables.

In instances where students have had bad experiences with mathematics or fear mathematical problems that entail extensive computation, the calculator allows students to concentrate on the solution to the problem. The calculator also permits them to verify and re-verify their answer as well as finding different methods of solving the problem by trial and error. Using the printing calculator the student has a printed record of the process and solution. He could also check for digit reversals and compare processes and answers. Since most calculators do not have printers and problems and

processes must be retained in the student's mind, the Sharp 5100 or 5010 with the LCD, rolling writer display-- is a solution. The rolling writer displays numbers, letters and symbols of up to 80 characters including direct formula entry with up to 15 levels of parentheses and 11 data memories (six for the 5101).

For the beginning, young, or exceptional student, the game-practice devices such as "Dataman" and "Little Professor" are highly motivational for reinforcement and drill. Perhaps the most important aspect of mathematics for the slow, handicapped or potential dropout student, is learning basic arithmetic skills and their applications, such as the ability to make change and to use a cash register. The Cosis #C11Er Mini Electronic Cash Register has a quick print 11-digit system and 7-digit Digiton display with automatic change calculation, simple repeat registering, and is relatively inexpensive at \$99.95 and easy to use.

Students' confidence and motivation can be enhanced by the teacher's use of the "EduCale", a two display unit. It has the usual small, red numerical readout facing the teacher as he operates it, and a big display unit showing the same numerical display on the side facing the students. (The "EduCale" is distributed by Educational Calculation Devices, Inc., Laguna Beach, California). The Overhead Demonstration Calculator can also be seen by a classroom of students or a large audience (Distributed by Stokes Publ. Co., Palo Alto, California).

The Sharp 827 "Play a Tune" calculator has 11 music notes and plays a tune while math problems are solved. The additional aural clue would be helpful for the slow, partially-sighted student or the student with an aural-memory. The APH Student Plus Talking Calculator, which has 24 words of the vocabulary, keys from 1-10, four operations, equals, root, memory, etc. and six arithmetical functions, with keys with highly visual notations, is for

low vision students. (Distributed by American Printing House for the Blind, Louisville, Kentucky; price \$395.99). Panasonic also has a Talking Calculator (#Pan 1650) with audible and visual playback for the sight-impaired.

It appears the calculator will come to play a more prominent role in the classroom with regular and exceptional students. Recent research shows that mentally handicapped students who can be educated, in the main, do not acquire arithmetic skills much beyond the fourth grade level. The calculator can help the student exceed this level of achievement. However, special consideration needs to be given to adapting the device to the various special needs of handicapped students. The special adaptations should include large keys, large digital displays, and optimal, auditory responses for keying and printing. For the sight-impaired, braille keys and braille printer, tapes should be incorporated in the calculators.

A more recent instructional device that is being increasingly used in the schools is the microcomputer. It may replace the calculator in that the microcomputer performs all the functions of the calculator in addition to being easily programmed to store and retrieve specific requested data, ask questions, and evaluate and report students' responses. A computer is actually^a glorified calculator. Both do mathematical calculations. A calculator is usually capable of performing only one step at a time and does them at a very slow rate. Also, it can't store more than a couple of results at a time. A computer can take a large amount of information and perform a series of steps (a program that often contains thousands of lines of instructions). It can also store large amounts of information. Unlike the computers of a decade ago which filled several rooms and cost millions of dollars, the

microcomputer today, such as the TRS-80 or Apple, is a light-weight typewriter keyboard and small television monitor, costing, in many cases, less than \$1,000.00. The size of the keyboard and the display screen is compatible for use in schools. Displays are in black and white or color, depending on the model.

Unlike the larger computers, one does not need a strong knowledge of programming. Because of the large amount of pre-packaged programs or software now available it is not necessary to know much about programming. In most cases you simply load the program and proceed with the lesson or game.

On the other hand, microcomputers do not think. One must tell them what to do. This is called programming. Nor do microcomputers understand English. Computers must be told what to do -- step by step. (Everything they do must be reduced to the 1's and 0's of the binary language.) What a computer does understand and "speak" (respond) -- fluently -- is a "programmed language." Microcomputers have a program language called BASIC programming, which is easy to learn. Teachers and students can easily write their own programs. One can write a simple game, an arithmetic lesson, a class schedule, an IEP for special education student or a business program.

Computer Assisted Instruction (CAI) is an integral part of micro-computer "instruction". Computer-aided instruction is the process by which written and visual information is presented in a logical sequence to a student by a computer. The computer serves as an audio/visual device. The student learns by reading the text material presented or by observing the graphic information displayed. The primary advantage of the computer over other audio/visual devices is the automatic interaction and feedback that the computer can provide. Multiple paths through the course material can be taken, depending upon the individual student's progress. Courseware in multi-subject areas such as reading, mathematics, language arts, social studies,

science, etc., is becoming available for all grade levels. The courseware ranges from courses that teach kindergarten students to count to advanced courses in physics and statistics. Microcomputers have many of the same educational advantage as calculators. Instruction can be highly individualized. Micros can be diagnostic tools for evaluating students. They are non-threatening to the student and can be programmed to correct and give praise, e.g., "Very Good, John," or "Keep up the Good Work". The microcomputer is used as a supplementary approach to learning, drill and reinforcement. It extends the teacher's time to provide additional instruction and individualized help to other students. Its main value is as an effective technique for individual rather than group instruction. Students can learn at their own pace and convenience.

Specific applications of and learning using the microcomputer can best be illustrated via a discussion of the available educational programs or software.

There is EDU-PAK from EDU-Ware \$39.95 contains five programs -- "Compu-Read", and "Perception". We discuss a few of these programs:

"Compu-Read", designed to improve a reader's speed and retention, begins with a choice of six different programs. "Compu-Read 1" places three random letters on the screen for a brief moment. The user must type these letters after they have vanished. If he succeeds, the next set of letters remains on the screen for a shorter period of time. If he is wrong, the time of display increases. At the end, the time of display is shown, as well as the number of letters per second for both the start and end of the segment. This information helps the user gauge his progress.

"Compu-Read 11" uses words instead of random letters. At this stage, the skills developed in the first program are called into service. Skills related

to recognition are also emphasized and strengthened in this exercise. "Compu-Read III" displays a word on the left and four words on the right. One of the four is either a synonym or antonym for the word on the left. Once again, the words do not remain on the screen for long. The user must type the correct synonym or antonym. This involves both recognition of the words and comprehension of their relationships. The system can train a person to absorb and analyze data in a rapid manner.

"Compu-Read IV" presents a sentence, then asks the reader a question concerning the sentence. The question is always about either the subject or object, thus training the user to scan quickly for information. This technique can greatly increase reading speed. Another program is "Missing Facts" (\$29.95) which can be used by a student with no help from a teacher. In "Math Table Drill" (see above), problems are presented with one missing factor -- $5 + ? = 9$ - and the user has to supply this missing number. After a correct answer, the whole problem is displayed again. When the guess is incorrect, three chances are given before the computer provides the answer.

Flash Spelling (\$14.95) presents words one letter at a time in large script. The whole word remains on the screen for an instant, then vanishes. At this point, the user must correctly spell the word. The benefit of this program is that it reinforces learning. By seeing the word one letter at a time, the student is more likely to remember the correct spelling.

Scrambled Letters (\$14.95) is for two players, who take turns trying to solve jumbled words. If a player is correct, his opponent gets a new word; on an incorrect guess, the other player gets a shot at the same word. If they both miss twice, the program shows them the word. Extra points are given for speed in this contest.

Introduction to Mathematics on the Computer (\$29.95) presents the student

with math problems at a specific selected level of difficulty. If the student does well, the level increases. The value of the program becomes apparent when the student makes a mistake. After several tries, if the answer hasn't been found, the machine restates the question as a word problem. Instead of using "5+3," for example, it says, "Maybe this way would be easier for you: If I had 3 pencils and you gave me 5 more, how many pencils would I have?"

Another interesting program is States and Capitols (\$14.95). A high-resolution map of the USA is displayed. One at a time, the states are outlined. The player has to guess the state. If he is wrong, the program will tell him the answer. After that, he has to guess the capitol. Again, the correct information is provided after each guess. The game is nicely designed, but would be best used in a classroom, since individuals who used it would quickly learn the states and have no more need of the program.

A nicely packaged program is "Music Composing Aid," (\$11.95). Which allows the entry of notes, the replay of the notes or of other saved scores, and the editing of compositions. The music, coming from its own speaker, sounds like an alto recorder. When using the system for composition, each note is played as it is entered. Notes are coded using a simple method. A. C. below middle C is entered as C. To go an octave higher, the composer would use CC. There is a range C below middle C to C three octaves above middle C. Along with the program is a data tape containing a Bach composition. The program encourages students to learn musical notation so they can transpose their favorite scores from sheet music into computer data. This package offers a nice variety of programs, and would be worth the price for the music routines alone. This is only a sample of the educational programs available, there is a lot of educational software available. The quality is getting better and the prices should come down.

USED

The following criteria should be in the evaluation of instructional software packages: * Human engineering aspects: e.g., attractiveness of display, ease

of operation, etc. * Adequacy of task analysis: are all the subskills identified? * Completeness of subject-matter coverage. * Adequacy of basis for instructional decisions.

Software presently available includes a teacher-aide program for determining class grade distribution, an IEPs program for special education students, class listing, equipment and book inventories, cumulative achievement score reporting, and health and psychological data records for individual students and the class. The microcomputer can store and make printed copies of all information. These data are stored on cassettes or diskettes. The data can also be edited and revised without retyping the original information.

One of the most important questions is what types of microcomputers are available and which one should one purchase. First, spell out exactly what you expect from your own microcomputer -- today and years to come. Visit computer stores, read journal articles, talk to educators who use them in their schools and get advice from those who distribute and sell microcomputers. Learn to operate one yourself. In short, become familiar as possible with the various instruments.

In terms of determining which of a dozen computers to purchase follow the foregoing advice. Following is a comparative list of some of the most popular microcomputers:

Apple II Plus

TRS-80 Level II

Health WH89

Atari 800

Commodore PET/CBM.

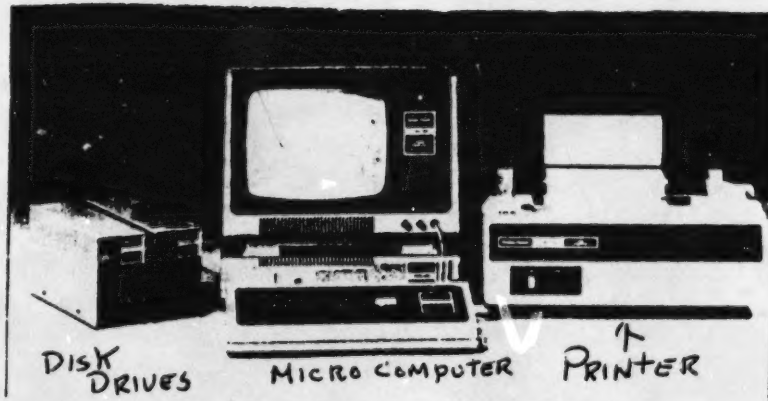
Description of System	Keyboard and CPU in a plastic case with metal bottom	Keyboard and CPU in single black plastic unit, cassette and monitor in separate units.	Keyboard, CPU, monitor and disk in metal case.	Keyboard and CPU in plastic case with metal shielding, cassette in separate unit.	Keyboard, CPU and monitor in a single metal unit.
Memory *	16-48K RAM(8K Basic, 4K monitor, 4K hardware switches)	4-48K RAM 16K ROM	16-48K RAM 6K ROM	16-48K RAM up to 26K ROM	8-48K RAM 16K ROM
Computer Other available language	Integer Basic, Pascal, Pilot	Fortran	Pascal	Pascal (1981) Microsoft Basic (1981)	None
Graphics and color	40 x 48 with 16 colors, 280 x 192 with 6 colors	B·W 48 x 128 using graphics characters with 3 x 2 blocks, giving programmable control of 16 x 64	33 graphics characters available, each composed of an 8 x 10 matrix B·W	Several Modes, from 40 x 24 with 4 colors to 192 x 320 with 2 colors	B·W. special graphics symbols 25 x 40 display
Text	24 x 40 upper case	16 x 64 upper case	24 x 80 upper and lower case	24 x 32 upper and lower case	25 x 40 upper and lower case
Sound Capabilities	Built in speaker	Through peripherals	Through external devices	4 voices plus speaker	Through external devices
Outside Software availability	Excellent	Excellent	Little	Fair, getting better	Good

	Apple II Plus	TRS-80 Level II	Health WH89	Atari 800	Comodore PET/CBM
Outside Hardware availability	Excellent-including boards for speech and music, light pen, printers, bit pads, and joysticks	Excellent, including music, speech, light pens, and printers	Little	Little	Good, including music boards, S-100 expansion interface, and joysticks
Dependability	Good	Fair	Good	Good	Good
Service	Available at all authorized dealers. Quality varies	From 86 service centers across the country	Through health service Centers	From many dealers or Control Data Centers	Available at some dealers or mail in
Price of Basic System	\$1195 for 16K	\$649 for 4K \$768 for 16K	\$1195 for 16K Kit without Disk	\$1080 for 16K	\$995 for 16K
Price of System with Disk **	\$1950 for 32K with Disk	\$1580	\$2895 for 48K with Disk, assembled	\$2000 for 32K with Disk	\$2590 for 32K with dual Disks
Comments	An established machine with continuing support from Apple and other manufacturers. many active users groups	A very popular computer with many users groups. Available software and hardware will continue to grow.	Health has an excellent reputation in the electronics field. The use of RAM for language allows many future applications.	The Atari is growing in popularity. Many vendors will probably be adding Atari prods. to their lines of software and hardware.	A nice unit with some good features, especially popular with educators since it is self contained.

* The amount of information that can be stored. (64K stores more information than 16K.)

** A disk (floppy); similar to a phonograph record that stores information and programs.

Below is a picture of a TRS-80 with various components. The Disk Drive, similar to record player, records, stores and playback information through the computer. The Printer is an instrument, similar to an automatic typewriter, that produces a printed copy of the information in the microcomputer.



An innovative device developed for the microcomputer is the speech synthesizer. It can be programmed to respond orally to the student's typed question, statements or responses. It could be helpful to the non-verbal or visually impaired student. A more recent innovation in microcomputers is the "Talk Box" in which the microcomputers are programmed to be sensitive to the nuances of a particular voice.

As an instructional aide for exceptional students the microcomputer appears to have great adaptability. It can measure the student's performance and adjust the difficulty of the problems in a non-threatening manner. As the student successfully completes a skill or a concept the microcomputer can generate more difficult problems, as illustrated in the sample programs. It can also provide easier problems when the student indicates, by his responses, that he is having difficulty.

Calculators and microcomputers are here to stay. With the reduction in school budgets and the given need to provide individualized instruction (IEP's) and to mainstream exceptional students, the inclusion of these devices as instruction tools seem inevitable. The calculator and the microcomputer are the first instructional devices available to all students.

In summary, both of these instructional devices can benefit students by:

- Reinforcing the basic skills
- Helping in the basic skills of reasoning
- Reinforcing problem solving ability
- Promoting logical thinking
- Encouraging creativity
- Develop concentration and independent learning.
- Broaden technological experiences.

Providing stimulation and motivation

Develop map reading skills

Helping to develop number sequencing concepts

Aiding in discovering mathematical concepts

Develop music skills.

All of this has important implications for teacher education.

Changes in methods of teaching will take place. It is essential that those who will teach future citizens be prepared to introduce them to the tools which they will use and which will affect their lives in so many ways. Teachers must be trained to use calculators and microcomputers in educational settings.